Stability of women's facial shape throughout the menstrual cycle

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Abstract

Facial characteristics can serve as a cue for judgements of multiple human traits, from maternal tendencies, overall fertility to sexual openness. In this study, we tested previously found fluctuations in facial shape throughout the menstrual cycle. With methods more robust than those formerly used (larger sample size and detailed hormonal assessments determining the timing of the ovulation) we did not find significant changes in either of the three facial measurements conducted: symmetry, averageness and sexual dimorphism (all $F \leq 0.78$, all partial $\eta 2 \leq 0.01$, all $p \geq .542$). After narrowing the sample to cycles that had a higher probability of being ovulatory (based on daily measurements of luteinizing hormone and estradiol), the results remained non-significant (all $F \leq 1.20$, all partial $\eta 2 \leq 0.03$, all $p \geq .315$). Our results 1) suggest that the previously found increased facial attractiveness of women in the most fertile phase of the menstrual cycle is not driven by changes in facial shape, but might instead stem from other changes in facial appearance, such as a more attractive skin tone, 2) underline the importance of replication of studies with new methods.

Keywords: Symmetry; Averageness; Sexual Dimorphism; Facial Cognition; Menstrual Cycle; Cyclical Changes.

Introduction

Facial attractiveness is of critical importance for social interactions (1, 2). Humans use facial features to choose partners and to infer health (3), sexual openness (4), social status (5), and maternal tendencies (6). Understanding attractiveness judgments can therefore provide important insight into human daily interactions. Although facial attractiveness has some idiosyncratic components ("beauty lies in the eye of the beholder"), research has also established several aspects of facial appearance that are consistently associated with attractiveness across perceivers, including face shape and colour cues. Other research has suggested women's attractiveness might be linked to current fertility status (7). In this study we discuss three aspects of face shape often associated with attractiveness – facial symmetry, averageness, and sexual dimorphism – to identify possible physiological sources of variation in women's facial attractiveness during the menstrual cycle.

Background

Facial Symmetry

Symmetry, or more precisely, the absence of fluctuating asymmetry, has been a focus of attractiveness research for several decades (8, 9). Fluctuating asymmetry is defined as a random "deviation from ideal symmetry in bilateral physical traits that do not display any directional tendency" (10). It is thought that the magnitude of facial asymmetries can serve as a proxy for gauging how efficient an organism has been in developing bilaterally while facing environmental obstacles (such as energy shortages or pathogen infections) (11). That is, symmetry is thought to be a cue to developmental stability, indicative of heritable genetic quality (12). In line with this reasoning, facial symmetry has been linked to both actual (13) and perceived health (9, 15, 16), though recent work using sizeable samples failed to replicate a relationship with measures of actual health (14, 17).

Facial averageness

Averageness was first introduced as relevant to facial attractiveness by Langlois and Roggman (18), who reported that composite images of multiple individuals were, on average, perceived as more attractive than images of individual faces. While this increased attractiveness was later shown to be partially an artefact of how early averageness visualizations were created (e.g., 19), several studies have since confirmed that averageness is linked to attractiveness (although the most attractive faces are not average, e.g., 20, 21). Several explanations for this link have been proposed. First, an average facial appearance might indicate a heterozygous genotype, signaling the genetic diversity important in defending parasites and pathogens (e.g., 22). Second, average or prototypical faces might be preferred because of an avoidance of extremes (e.g., 23, 24) and/or a preference for prototypicality itself due to increased perceptual processing fluency (e.g., 25, 26).

Facial sexual dimorphism

Dimorphism in secondary sexual traits is thought to develop under the influence of sex-specific ratios of androgens and estrogens. Examples of sex-typical facial features in men are broader jaws and a more pronounced brow ridge. Examples of sex-typical facial features in women are generally smaller features and fuller lips. While the attractiveness of masculine male facial features has been intensely debated (e.g., 27, 28, 29), there appears to be a consensus in the literature that feminine facial features in women are attractive (though the extent to which femininity affects women's perceived attractiveness may be smaller than previously assumed, e.g., 30, 31). Facial sexual dimorphism has been linked to health in both men and women ((3), but see (32-35) for recent doubts regarding the link of sexual dimorphism and health in men) and in women it has also been linked to reproductive success (36), and stronger maternal tendencies (6).

Cyclical fluctuations

It has been suggested that women's preferences and behavior change throughout the menstrual cycle in response to fluctuations in sex hormones and conception probability. Cyclical changes have been reported for facial preferences (for meta-analyses, see 37, 38), sexual behaviors (39), choice of clothes ((40), however see (41)), and women's gait (42). It has also been suggested that women's facial appearance changes throughout the menstrual cycle; faces are perceived as more attractive when photographed around ovulation than during the less fertile parts of the cycle (7, 43). These reported changes in women's attractiveness over the menstrual cycle might be linked to cyclical changes in the aspects of facial appearance discussed above.

Two earlier studies found that the magnitude of body symmetry fluctuates across the menstrual cycle. Based on the length of ears and third, fourth and fifth digits' of fewer than 20 participants, Scutt and Manning found a 29% decrease in asymmetry on the day of ovulation (defined as the first day of follicle collapse observed via trans-abdominal ultrasonography) in comparison to one or two days prior (44). They suggested that changes in asymmetry are caused by cyclical changes in hormonal levels which affect women's soft tissues. Another study from the same year showed a significant U-shaped relation between day of the cycle and overall asymmetry as measured from ear and digit lengths (45), but a pre-ovulatory peak in asymmetry was visible in many cases. In the same article, Manning and colleagues reported that breast asymmetry had an inverted U-shape relation across the cycle, peaking around day 14 (however, the day of the cycle accounted for only around 5% of the variance in asymmetry).

In a more recent study based on 100 participants, Cetinkaya and colleagues found that women's facial symmetry changed among 5 weekly measurement across one menstrual cycle, being lowest around ovulation (46). However, this study used an unreliable method of establishing ovulation, i.e. a counting method based on the date of the start of the current menstrual cycle (47).

Taking a more computational approach, a recent study assessed the facial appearance of 20 women photographed around ovulation and in the luteal phase using geometric morphometric methods (48). Ovulatory faces were chosen as more attractive than luteal ones, and they differed in their shape: images taken in the luteal phase were more asymmetric.

Aim of the study

In the current study, based on a sample of 75 regularly cycling women, we tested whether measurable components of facial appearance fluctuate throughout the menstrual cycle. A typical ovulatory menstrual cycle starts with a follicular phase of an average length of 14 days during which a follicle develops. After the follicle matures, ovulation occurs. Increased doses of estradiol are secreted from the ovary at the end of the follicular phase. In the subsequent luteal phase, levels of progesterone rise, reaching their peak on average one week before the onset of menses. The third hormone that orchestrates functioning of the menstrual cycle is luteinizing hormone (LH), which usually peaks just before the ovulation. Together with changing levels of estradiol (49), the LH peak can be used as a reliable physiological estimate of increased conception probability (50). In the current study conception probability throughout the cycle was thus estimated by daily Luteinizing Hormone-based ovulation tests and estradiol measurements. Facial symmetry, averageness and sexual dimorphism were measured using landmark-based geometric morphometric methods at three different points during the menstrual cycle: in the early follicular, peri-ovulatory and luteal phases.

Materials and Methods

Participants

102 women participated in the study (M_{age} = 28.8 years, SD = 4.6 years) as part of a larger research project conducted in 2014-2019 (51). Eighteen participants did not have all three photographs throughout the measured menstrual cycle and nine attended the second meeting more than 72 hours after a positive result of the LH ovulation test. Of the remaining 75 women, in 35 an estradiol drop was observed after obtaining a positive LH test result.

Visual Stimuli Creation

Photographs of women were taken on three separate occasions throughout the menstrual cycle. The first photograph was taken during the early follicular phase, on average 5 days after the onset of the last menses (SD = 2.0 days). The second photograph was taken around ovulation, on average 13 days before the onset of the last menses (SD = 3.4 days), not later than 48 hours after obtaining a positive LH test result. The third photograph was taken on average 5 days before the onset of the next menses (SD = 3.2 days). To establish the timing of the second photograph, two hormonal measures were used to detect increased conception risk. The first was the LH ovulation kit that women administered starting from day10 of the cycle until day 20 or until obtaining a positive result. The second fertility measurement was a post-hoc salivary estradiol (E2) measurement, as the greatest drop of E2 within the cycle is an adequate measure of ovulation (49). The post-hoc measurement was used for narrowing subsequent analyses to women who experienced both a peak in LH and a pronounced drop in E2. This group had higher probability that the cycle during which the photographs were taken was ovulatory.

Shape analysis of face images

Face images were delineated with 124 landmarks in PsychoMorph (52), Procrustes-aligned using the R package *geomorph* v3.0.6 (53) and subjected to a principal component analysis (Figure 1). Images were delineated in a random order to prevent any systematic errors in the annotation of images from the three different time points. The broken stick criterion was used to select principal components (PCs) to be used in subsequent analyses (54). Facial asymmetry, averageness, and sexual dimorphism were assessed using standard methods described in Holzleitner et al. (55; for more details and analysis code, see https://osf.io/drtg9/). Facial asymmetry was calculated as the Euclidean distance between each woman's original and mirrored set of shape coordinates. Averageness was calculated as the Euclidean distance of each woman's face shape coordinates from the sample average. Sexual dimorphism was calculated by projecting individual women's faces on a PCA shape vector describing shape differences between an average male and an average female face from a different study (55).

Figure 1. Example of a template with 124 landmarks.

Statistical analysis

Analyses were conducted using R v3.6.1(56) . Data and analysis code are publicly available at https://osf.io/drtg9/. Asymmetry, averageness, and sexual dimorphism scores were z-transformed and entered into a repeated-measures ANOVA using the R package *afex* v0.25-1 (57). We tested whether images taken at the three different points in the menstrual cycle (within-subject factor "time in cycle", I=early follicular phase, II=ovulatory phase, III=luteal phase) differed in asymmetry, averageness, and sexual dimorphism (within-subject factor "measurement type").

Results

The repeated-measures ANOVA showed that none of the shape scores changed across the menstrual cycle. Neither main effects of "time in cycle" or "measurement type", nor the interaction of "time in cycle" x "measurement type" were significant (all $F \leq 0.78$, all partial

$\eta^2 \leq 0.01$, all $p \geq .542$, Figure 2). When we repeated the analysis separately for individual, non-standardized shape measurement scores (with "time in cycle" as the sole within-subject factor), results showed the same pattern of non-significant effects (see supplemental material).

Figure 2. Results of the measurements repeated three times during the menstrual cycles: I=early follicular phase, II=ovulatory phase, III=luteal phase (bars indicate within-subject standard errors).

We also ran identical analyses on a subset of women who experienced an estradiol drop after obtaining positive results from the LH test (N=35). Again, we found no evidence for a change in asymmetry, averageness, or sexual dimorphism based on time in cycle (all $F \leq 1.520$, all partial $\eta^2 \leq 0.03$, all $p \geq .315$; see supplemental material).

Discussion

In this sample of 75 regularly menstruating women, we did not find variation in facial shape that covaried with the menstrual cycle phase. To account for possible inter-participant variation, we then narrowed the sample to only those women who experienced a decrease in estradiol after obtaining a positive result of the LH test. This limited the sample to cycles where ovulation was highly probable. Again, no significant variation in facial shape was found.

Concealment of ovulation?

In line with earlier findings of a lack of variation in digit ratio symmetry (58), these results do not support reports of symmetry fluctuations in facial images (46, 48) and other body measurements (44, 45) across the menstrual cycle. Current results also provide computational support for the previously published studies that did not find changes in how raters judged attractiveness based on current fertility. Lobmaier (2016) did not find changes in women's rating of other women's faces depending on their current fertility (59) and used visual stimuli that were created in a manner as robust as in the current study, where both LH tests and post hoc sex hormone levels were measured (however they did find some perceptual change, that was not related to judgements of attractiveness). In a sample of 17 women, Bleske-Rechek and colleagues did not find that the judgement of female attractiveness depended on their conception probability (60). However, those authors estimated conception probability by counting back from the onset of menses, a method we show here to be inaccurate. The more robust method of hormonal measurements used in the current study more accurately defines periods of heightened conception probability (47, 61) and provides computational explanations for their null results.

Our analysis cannot provide possible explanation for the results of the previous studies that found within-cycle variation in judged facial attractiveness. What we can say is that previously found changes in the attractiveness judgements most probably were not based on changes in symmetry, averageness or sexual dimorphism. For example, Bobst and Lobmaier (2012) reported that men judged women's faces as more attractive if they were photographed during a period of high fertility, replicating the result of a previous study (7). Because the judgement of attractiveness was positively related to conception probability (as manipulated by transforming the faces to resemble peri-ovulatory faces by either 50 or 100% percent), they suggested that subtle changes are sufficient for the ovulation detection. However, because those authors did not measure facial features, it is impossible to know why judgements differed (i.e., what facial characteristics drove the change in attractiveness) or how subtle detectable these changes can be.

Cyclic variation in skin tone rather than shape?

Our finding that facial measurements do not change across the menstrual cycle suggests that the previously found cyclical changes in attractiveness judgements (7, 62) were probably not based on these three facial shape features. Other recent study also has failed to support an association between symmetry, sexual dimorphism and facial attractiveness (31). It is possible that women in their most fertile phase exhibit a more attractive skin tone, which translates into heightened perceptions of attractiveness and femininity (63). However, we could not test this hypothesis because the photographs used in this study were not sufficiently standardized with regards to lighting (photographs were taken at different times of the day, under both artificial and natural lighting).

Hormonal underpinnings of facial physiognomy

The changes in attractiveness judgements found in some of the previous studies might also be a by-product of changes in hormonal levels. As women who have higher levels of progesterone were found to be more attractive ((64) but see (65)), it is possible that overall sex hormone levels rather than daily fluctuations of conception probability correspond better to the inter-individual differences in facial measurements. As levels of sex hormones vary greatly among women (see 66 for results based on the sample of women used in the current study), measurements of faces in three distinct moments of the cycles would contain too much noise caused by the inter-individual variation in hormone levels to allow one to detect an effect of current fertility. This idea remains to be tested.

Conclusions

In a sample of 75 women, we did not find variation in facial symmetry, averageness and sexual dimorphism as measured from photographs at three different points in the menstrual cycle that vary in conception probability. The method used to gauge fertility was robust, for it measured two separate hormone levels. Thus, our findings do not support the hypothesis that facial shape (namely symmetry, sexual dimorphism or averageness) changes depending on conception probability. Our results suggest that earlier claims that fertility affects facial attractiveness were not based on changes in facial shape, as described by three measured features, but rather were mediated by other mechanisms (e.g., changes in skin tone). They also demonstrate that replication of studies combined with novel methods and novel samples is crucial.

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